SİDAS MEDYA
Akademik Gıda®
ISSN Online: 2148-015X
https://dergipark.org.tr/tr/pub/akademik-gida

Akademik Gıda 19(4) (2021) 373-380, DOI: 10.24323/akademik-gida.1050750

Research Paper / Araştırma Makalesi

Morphometric and Physico-chemical Properties of Cornelian Cherry (*Cornus mas* L.) Grown in Çorum, Turkey

Nihal Güzel

Department of Food Engineering, Faculty of Engineering, Hitit University, Çorum, 19030, Turkey

Received (Geliş Tarihi): 16.09.2021, Accepted (Kabul Tarihi): 11.12.2021
Corresponding author (Yazışmalardan Sorumlu Yazar): nihalguzel@hitit.edu.tr (N. Güzel)
+90 (364) 227 4537 +90 (364) 227 4535

ABSTRACT

Cornelian cherry (*Cornus mas* L.) has regained an increasing interest because of its nutraceutical and pharmaceutical potential. This study was designed to investigate the phenolic compounds (total phenolic, flavonoid, hydrolysable tannin, proanthocyanidin and anthocyanidin) and antioxidant capacity of Cornelian cherries. Some morphological (length, width, weight, flesh:seed ratio and colour) and physicochemical properties (dry matter, pH, soluble solid content, total acidity, sugar profile and ascorbic acid) of Cornelian cherries were also examined. Cornelian cherry samples were selected from twelve locations in the Çorum province of Turkey, where they are grown natively. Bioactive compounds were extracted by an ultrasound assisted method (37 kHz frequency and 100% amplitude) for 20 min at 20±2°C. Aqueous methanol (70%) was used as extraction solvent with the solid:solvent ratio of 1:20. Glucose (3.02±0.9%) and fructose (1.57±0.4%) were found as the main sugars in cherry fruits. The CIE* colour values ranged from 25.18 to 33.00 for L*, 9.74 to 30.26 for a*, 2.46 to 14.41 for b* values. Total phenolic content, flavonoids, total anthocyanin, proanthocyanins, hydrolysable tannins, ascorbic acid and antioxidant activity varied between 230.4–559.8 mg GAE/100 g, 28.3–94.7 mg CE/100 g, 69.2–200.5 mg/100 g, 124.1–316.3 mg CE/100 g, 151.6–568.9 mg TAE/100 g, 29.0–103.3 mg /100 g, 24.4–92.5 µM TE/g, respectively. Antioxidant activity was positively correlated with bioactive content of Cornelian cherry fruits ($p<0.001$). The native Cornelian cherry population with the high antioxidant potential may be useful for future breeding programs, organic production or as food additive.

Keywords: *Cornus mas* L., Fruit quality, Phytochemicals, Antioxidant capacity

Çorum'da Yetişen Kızılcıkların (*Cornus mas* L.) Morfolojik ve Fiziko-kimyasal Özelliklerinin Değerlendirilmesi

ÖZ

Kızılcığa olan ilgi sahip olduğu nutrasötikler ve farmasötik potansiyeli nedeniyle yeniden artmaktadır. Bu çalışma kızılcıkların fenolik içerikleri (toplam fenolik, flavonoid, hidrolize tanen, proantosiyanidin ve antosiyanidin) ve antioksidan kapasitesinin araştırılması için planlanmıştır. Ayrıca bazı morfolojik (meyve boyu, genişlik, ağırlık, meyve eti:çekirdek oranı ve renk) ve fiziko-kimyasal özellikleri (çözünür kuru madde, pH, toplam asitlik, kuru madde, şeker profili ve askorbik asit) de belirlenmiştir. Kızılcık örnekleri Çorum bölgesinde doğal olarak yetiştiği 12 farklı lokasyondan toplanmıştır. Biyoaktif bileşenler ultrases (37 kHz frekans ve %100 genlik) yardımıyla 20±2°C'de 20 dakika süresince ekstrakte edilmiştir. Ektraksiyon 1:20 katı:solvent oranı ile %70'lik sulu metanol kullanılarak yapılmıştır. Glukoz (%3.02±0.9) ve fruktoz (%1.57±0.4) kızılcık meyvesinde bulunan başlıca şekerler olarak saptanmıştır. CIE* renk değerlerinin L* değeri için 25.18 ile 33.00, a* değeri için 9.74 ile 30.26, b* değeri için ise 2.46 ile 14.41 arasında değiştiği belirlenmiştir. Toplam fenolik, flavonoid, toplam antosiyanin, proantosiyanin, hidrolize tanen, askorbik asit miktarları ve antioksidan kapasiteleri sırasıyla 230.4–559.8 mg GAE/100 g, 28.3–94.7 mg CE/100 g, 69.2–200.5 mg/100 g, 124.1–316.3 mg CE/100 g, 151.6–568.9 mg TAE/100 g, 29.0–103.3 mg /100 g, 24.4–92.5 µM TE/g arasında değiştiği

tespit edilmiştir. Kızılcık meyvesinin biyoaktif bileşen içerikleri ile antioksidan kapasiteleri arasında güçlü pozitif korelasyon bulunmaktadır ($p<0.001$). Doğal olarak yetişmekte olan kızılcıkların sahip oldukları güçlü antioksidan potansiyel nedeniyle ileride yapılacak kültüvasyon çalışmaları, organik üretim ya da gıda katkısı olarak kullanımının faydalı olacağı düşünülmektedir.

Anahtar Kelimeler: *Cornus mas* L., Meyve kalitesi, Fitokimyasallar, Antioksidan kapasite

INTRODUCTION

Fruits are considered as valuable source of antioxidant such as phenols and ascorbic acids [1]. Increasing the antioxidant rich diets is recommended to prevent oxidative stress which is highly related the most of acute and chronic diseases. Cornelian cherry (*Cornus mas* L.) has been used in folk medicine for centuries in mainly Europe and west Asia regions for preventing a number of diseases [2]. The Cornelian cherry leaves, flower, seed oil and barks as well as fruits are used to make galenic treatments for inflammations, gastrointestinal disorders, diabetes, cancer and cardiovascular diseases [3]. In addition, Cornelian cherry fruit is used as natural astringent flavor and cosmetic purposes [4]. The astringent flavor is related with water soluble tannins represented as an important secondary plant metabolite [5]. The anticarcinogenic, antibacterial, antiviral and anti-inflammatory activity of tannins also related with antioxidant capacity which act as total radical scavenging activity, chelator with metals, protector cellular oxidative damage [6].

Cornelian cherry fruits are significantly rich in wide diversity antioxidative phenolic compounds (anthocyanin, flavonoids, phenolic acids and tannins) and ascorbic acid [3]. Anthocyanins, which are natural colorant and antioxidant, has a potential on management and preventing diabetes [7]. Cornelian cherry fruit is also rich source of ascorbic acid in comparison with some berry type fruit [1] . Until recent researches, Cornelian cherry has been less preferred due to unusual flavor in daily fresh fruit consumption. Cornelian cherry has become more popular due to nutraceutical and pharmaceutical ingredients with the increasing healthy eating demand of consumer [8]. Today, various recent techniques have been explored to extraction these compounds in fruit matrices in order to increase extraction efficiency, minimize processing time and solvent exposure [9]. Ultrasound assisted extraction utilize the acoustic energy to achieve improved mass transfer [10]. Compared to conventional techniques, the new ecofriendly process are practiced enhanced recover the thermolabile compounds such as anthocyanins, with the minimize bioactive compound degradation [9].

Increasing number of studies in natural population and breeding of Cornelian cherry have been started with the increasing demand of these fruits considered as healthy food. The breeding programs of Cornelian cherry have been carried out mostly in Europe for almost last two decades [11]. In Turkey, the large number of Cornelian cherry cultivation field has native seedling phenotypes with wide range genetic variation whereas very limited studies have been carried out the selection of Cornelian cherry [12, 13, 14, 15] . Previous studies indicated that preserving the germplasm source is related closely with the genetic diversity [16]. However, native and semi-wild genotypes have been disappearing rapidly day by day during the last two decades [17].

The selection and collection of promising Cornelian cherry cultivar provide a source of further breeding programs [11]. The purpose of this study was to investigate the morphometric measurement (weight, length, width and flesh:seed ratio) physicochemical properties (colour, moisture, pH, soluble solid content, total acidity, sugar profile and ascorbic acid) and phytochemicals (total phenolic content, flavonoid, proanthocyanidins, hydrolysable tannins, anthocyanins and antioxidant capacity) of native Cornelian cherry phenotypes to conserve native source for further breeding programs, organic production or as food additive.

MATERIALS and METHODS

Collection and Preparation of Cornelian Cherry Samples

Uncultivated Cornelian cherry samples were used in this study. Cornelian cherries were harvested in 2018 from 12 different locations in Çorum province in Turkey. At each location, 2 kg Cornelian cherry fruits were sampled from two representative outlets. Physicochemical analyses were carried out with fresh fruits at sampling day. Rest of the samples were stored at -20°C until further chemical analyses. All experiments were carried out in duplicates.

Morphometric and Physicochemical Analyses

One hundred Cornelian cherry fruits were randomly selected for each replica, and weighted with an accuracy of 0.0001g. Flesh:seed ratio was calculated as described by Demir and Kalyoncu [13]. Fruit weight and length were measured at the same randomly selected representative samples by Vernier caliper with an 0.01 mm accuracy. The measurements were recorded in L* (Lightness), +a* (redness), +b* (yellowness) CIE (Commision Internationale del'Eclairage) colour coordinates by using Minolta CM 3600d spectrophotometer (Minolta, Osaka, Japan). Before use, the instrument was calibrated with a white tile and the measurement was carried out with 30 fruit samples [17]. Analysis were done in 2 replications for each sample.

The moisture content analysis of samples was carried out with the AOAC 934.06 official method [18]. Fruit seeds were removed manually and the fruit flesh was homogenized by Ultra-Turrax (Heidolph, Schwabach, Germany). Five g of homogenized sample was dried at

70±0.1°C for 14 h. Moisture analyses were repeated three times. The soluble solid content (SSC) was measured by Abbe refractometer (Atago, Japan). pH was measured with a pH meter (Adwa AD1000 pH/mV & Temperature Meter). Total acidity was determined according to Method 942.15 of the AOAC and expressed as g anhydrous malic acid/100 g sample [18].

Ascorbic acid content was measured by indophenol spectrophotometric method described by Raghu et al. [19] with a minor modification. A 60 g of the fruits homogenized in 60 mL of metaphosphoric acid solution (6%) by Ultra-Turrax to achieve fine homogenate. The homogenate was centrifuged at 5000 *g* for 10 min then was filtered. The colour intensity was measured at 520 nm compared with standard ascorbic acid solution (R=0.9999).

Extraction of Phytochemical Compounds

Phytochemical compounds extraction was performed in ultrasonic bath (Elmasonic P, Elma Schmidbauer GmbH, Gottlieb-Daimler, Singen, Germany). Extraction was carried out 37 kHz of frequency with 100% amplitude during 20 min. The temperature monitored and controlled at 20±2°C with circulating water. 70% methanol was used as an extraction solvent with 1:20 solid:solvent ratio. The extraction condition was determined with preliminary experiment at different frequency (37 and 80 kHz), methanol concentration (0─100%) and temperature (20, 60°C). The extract was centrifuged (Sigma 3K30, Germany) at 8000 *g* for 10 min at 4°C.

Total Phenolic Content

Total phenolic content (TPC) was measured by using colorimetric Folin-Ciocalteu assay as described by Singleton et al. [20]. 50 µl of Cornelian cherry extract was mixed with 2.2 mL of 0.2 N Folin regent and 1.6 mL sodium carbonate solution (7.5%). The solution was mixed and kept for 1h at room temperature under dark condition. The absorbance was measured at 760 nm in a spectrophotometer (Shimadzu UV-1800, Japan). The results were expressed as mg Gallic acid equivalent (GAE) per 100 g fresh fruit (R^2=0.9981).

Total Flavonoid Content

Total flavonoid content (FC) was measured using colorimetric method as described by Zhishen et al. [21]. One mL diluted extracts were mixed with 100 µL $NaNO_3$ (5%) and allowed to stand for 5 min. $AlCl_3$ (10%) was added to the mixture and allowed to stand for another 5 min before 1 mL NaOH (1.0 M) was added. The mixture volume was adjusted at 2.5 mL with distilled water and mixed well. The measurement was recorded at 510 nm. The content of total flavonoid was expressed as mg (+)-catechin equivalent (R^2=0.9990) per 100 g Cornelian cherry fruit.

Hydrolysable Tannin Content

Hydrolysable tannin content (HTC) was determined according to the spectrophotometric method described before by Çam and Hisil [22]. Diluted extract and 2.5% KIO_3 were vortexed for 10 s. The absorbance of red coloured mixture was measured at 550 nm versus the water blank. Tannic acid solution (50─2000 mg/L) was standard solution (R^2=0.9917). The results were expressed as tannic acid equivalent (TAE) per 100 g fresh fruit.

Condensed Tannins

Condensed tannins (CT) (proanthocyanidins) were measured using the vanillin assay described by Tanner and Brunner [23]. This method is based on reaction of the vanillin with C6 and C8 of catechin and leukoanthocyanins, the colour of the mixture turns to bright red and its intensity was measured at 500 nm. The absorptions of the mixtures in all tubes were measured at 500 nm. Quantification of CTs was carried out using calibration curve of catechin (50─200 mg/L) as an external standard. The content of total CT was expressed as mg of (+)-catechin per 100 g fresh fruit.

Total Monomeric Anthocyanin Content

Total monomeric anthocyanin (ACN) content was determined using the pH differential method described by Giusti and Worlstad [24]. Two buffer solution, pH 1.0 (potassium chloride, 0.025M) and pH 4.5 (sodium acetate, 0.4M) were mixed with sample extract. The absorbance of equilibrated solutions was measured at 515 nm (λmax) for anthocyanin content and 700 nm for haze correction. The difference in absorbance values at pH 1.0 and 4.5 was directly proportional to anthocyanin concentration. The results were calculated as cyanidin-3-glucoside (Cy-3-glu) equivalents with a molecular weight of 449.2 and an extinction coefficient of 26 900 L/cm mol.

ABTS Radical Scavenging Activity

Antioxidant activity (AOA) was measured according to ABTS method described by Arts et al. [25]. The ABTS method involved dissolving 7 mM ABTS (2,2′-Azino-bis, 3-ethylbenzothiazoline-6-sulfonic acid) in potassium phosphate buffer (pH 7.4) and combined with 2.45 mM potassium persulfate. The dark blue solution was diluted with potassium phosphate buffer (pH 7.4) until the absorbance reached 0.7±0.02 at 734 nm. 1 mL of the resulting solution was mixed with 20 µL of properly diluted sample extract or Trolox standard solution, and 6 min later the absorbance was measured at room temperature. The results were expressed as Trolox equivalent antioxidant capacity (TEAC mM). The concentration of standard solution ranged from 0.25 to 2 mM (R^2=0.9965).

Sugar Content by HPLC

Sugars were determined using HPLC (Shimadzu, Japan) with a quaternary pump, a refractive index detector, an auto-sampler, and a thermostatted column compartment. Samples were diluted and clarified with Carrez solution. 20 µL of filtered samples (0.45 µm) were injected into HPLC system. Sugars were separated on a Intersil NH_2 column (250×4.6 mm) (5 µm). Separation was performed with isocratic elution with 1.0 mL/min flow rate at 40°C

and the mobile phase consisted of acetonitrile and water (75:25) mix. Sugars present in samples were identified and quantified by external standard method.

Statistical Analysis

Correlation among experimental data was evaluated statistically with Pearson correlation coefficient by using IBM SPSS v. 20 software (IBM corp.).

RESULTS and DISCUSSION

Physical properties are the first stage for consumer acceptance. Cherry red colored and full fleshed fruits are more acceptable for consumer. The CIE* colour parameters were expressed in Table 1. The colour of Cornelian cherry fruits differed from cherry red to dark red colour. The fruit weight was ranged from 1.27 to 2.53 g. The average of fruit weight (1.81±0.31 g) was significantly higher than reported fruit weight (0.63±0.14 g) in literature [26]. Every region of Turkey has rich and diverse flora due to varied soil and climate conditions. The soil and climate conditions as much as cultivar/genotype are one of the major factors on physicohemical properties on plant. The average length (16.68±1.09) and width (11.74±0.76) were measured similar with previously evaluated genotype from different regions. Also, flesh:seed ratio of fruits (3.17–6.14) was in agreement with literature (2.0–9.4) reported by Ercisli [16]. Great variability was observed among the samples regarding soluble solids, dry matter and acidity (Table 1). The highest value of SSC, dry matter and acidity were 23.08%, 27.49% and 2.48 g/100 g (malic acid equivalent), respectively. Previously, Yilmaz [15] was reported the highest SSC as 21.17% for cultivated Cornelian cherry genotype 77-09. Demir and Kalyoncu [13] reported that the highest SSC was 19%, Pantelidis et al. [1] was also found the highest SSC as 14.4%. The average value of dry matter, acidity and pH were 19.89±3.00, 1.91±0.29 and 3.54±0.08, respectively (Table 1). Dry matter, acidity and pH were recorded between 15.88 and 28.19% [26], between 1.25 and 3.89% [15] and between 2.5 and 2.8 [13]. Glucose and fructose are the main sugars of Cornelian cherry fruit and ranged from 1.67 to 5.13% and 0.92 to 2.23%, respectively (Figure 1). Dinda et al. [3] reported similar glucose (2.5–7%) and fructose (2.2–3.8%) concentration for Cornelian cherry. Total sugar content of the fruit was between 7.6 and 15.4% [27].

Table 1. Morphometric and physicochemical properties of Cornelian cherry

Parameters	Range	Mean±SD
Width (mm)	10.38–13.49	11.74±0.76
Length (mm)	14.52–19.57	16.68±1.09
Fruit weight (g)	1.27–2.53	1.81±0.31
Flesh/seed ratio	3.17–6.14	4.17±0.78
Soluble Solids (%)	10.49–23.08	18.09±2.61
pH	3.41–3.69	3.54±0.08
Total acidity (%)	1.41–2.48	1.91±0.29
Dry matter (%)	14.43–27.49	19.89±3.00
Colour values		
L*	25.18–33.00	27.79±1.45
a*	9.74–30.26	17.80±3.95
b*	2.46–14.41	5.51±1.82
Individual Sugar (%)		
Glucose	1.67–5.13	3.02±0.90
Fructose	0.92–2.23	1.57±0.42

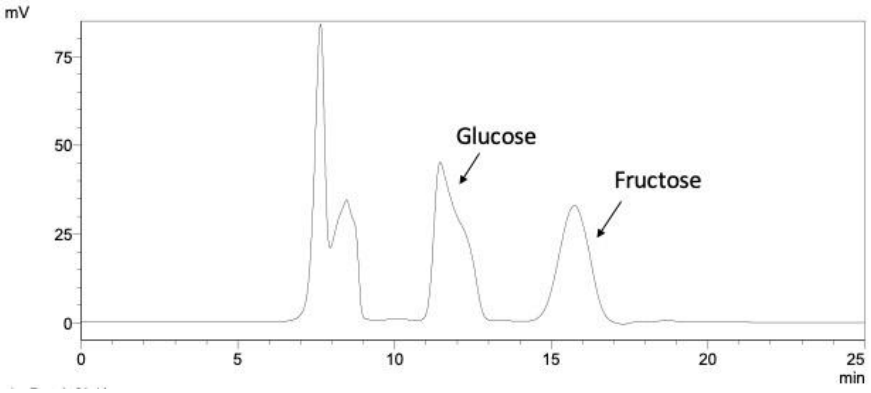

Figure 1. Sugar profile of Cornelian cherry sample

The total phenolic content of samples ranged from 230.36 to 559.82 mg GAE per 100 g fresh weight basis (Table 2). In previous studies, a wide variation was reported in the total phenolic content in Cornelian cherry fruit of 31.25±1.79 mg GAE/g [2], 26.59–74.83 mg GAE/g dry weight (DW) basis [15], and 1592±132 mg GAE/100 g DW [1]. Our results were in agreement with reported TPC of Cornelian cherry of 281–570 mg/100 g fresh weight

(FW) basis [26] and 209.5–305.5 mg/100 g FW [28]. Phenolic compounds are major bioactive components whereas bioavailability greatly differs between the various phenolic content.

Table 2. Phytochemical content and antioxidant capacity of Cornelian cherry

Parameters	Range	Mean±SD
Total phenolics (mg GAE/100 g)	230.4–559.8	348.7±87.3
Total flavonoids (mg CE/100 g)	28.3–94.7	56.6±16.8
Anthocyanin (mg/100 g)	69.2–200.5	119.7±38.8
ABTS (µmol TE/g)	24.4–92.5	46.3±15.1
Proanthocyanins (mg CE/100 g)	124.1–316.3	197.8±45.5
Hydrolysable tannin (mg TAE/100 g)	151.6–568.9	276.3±110.5
Ascorbic acid (mg AAE/100 g)	29.00–103.3	59.8±20.6

Flavonoids which have efficient bioactivity due to their hydroxyl group at various positions are one of the major phenolic of plant kingdom [2]. The total flavonoid content varied from 28.26 to 94.7 mg CE per 100 g FW basis. The average of total flavonoid content of fruit was 477.3±22.9 mg CE/100 g DW [29]. Pawlowska et al. [30] found that flavonoid content in Cornelian cherry was 221.3 mg/10 g. Methanolic extract of the fruit had a rich flavonoid glycosides composition. Quercetin 3-O-β-d-glucuronide was presented as a major flavonoid (69.9 mg/10 g) and followed by kaempferol 3-O-β-d-galactoside (41.3 mg/10 g). Celep et al. [2] expressed flavonoid content of Cornelian cherry as quercetin equivalent in an average 20.5±1.62 mg/g. The flavonoids with their subclasses, protect the plant against to pathogens and environmental stressors, and provide pigmentation to adapt to environment [31].

Anthocyanin, a subclass of flavonoids, contributed to pigmentation of plants and are exclusively responsible red, blue and purple colour of plant [32]. Cyanidin is the most prevalent anthocyanin, and the 3-glucoside is the most active antioxidant anthocyanin [33]. The highest monomeric anthocyanin content was 200.49 mg cyanidin-3-glucoside equivalents per 100 g FW basis. Similar anthocyanin contents were reported by Pantelidis et al. [1] (223 mg/100 g FW) and by Yilmaz et al. [15] (148–228 mg/100 g). Cornelian cherry had higher anthocyanin content when compared some berry type fruit such as blackberry (104–198 mg/100 g FW), raspberry-gooseberry (35–49 mg/100 g FW) and red current (1.3–7.8 mg/100 g FW) [1]. These results referred that Cornelian cherry seems to be a good anthocyanin source. However, the anthocyanin content and composition can be varied according to post harvesting processes [8].

Many flavonoids in foods are polymerized into large molecule during the usual metabolic process of plants, or as a result of food processing. The antioxidant activity of tannins has been affected polymerization degree that might be varied from two up to several hundred subunits. The large molecules are called as tannins and include condensed tannins (proanthocyanins), hydrolysable tannins and tannin derives [34]. Condensed tannins, proanthocyanidins, are oligomers or polymers of flavan-3-ol units [29]. Proanthocyanidin content of Cornelian cherry was found between 124.08 and 316.26 mg TAE per 100 g fruit of fresh based. Similar result (229±24.1 mg epigallocathechingallate equivalents per g extracts) was reported by Celep et al. [2]. Also, Milenković-Anđelković et al. [35] demonstrated that among the flavan-3-ols, (+)-catechin (3.91–3.95 mg/g DW) was predominant and followed by (–)-epicatechin (2.02–2.11 mg/g DW) and procyanidin B2 (1.55–1.61 mg/g DW). The hydrolysable tannins content in fruits was in the range of 155.63 and 346.70 TAE per 100 g fruit. Tannins are ellagic acid (ellagitannins) and gallic acid (gallotannis) esters and contribute on particular astringent taste of fruit [36]. Total tannin content of Cornelian cherry fruit was determined between 131.51–601.2 mg/L [13]. Dinda et al. [3] reviewed that tannin content of Cornelian cherry was in wide ranged between 0.6 and 14%. The Cornelian cherry fruits are great source of tannins when compared many fruits [17].

Cornelian cherry also represented as one of the main sources of ascorbic acids [37]. A wide variation was observed among the ascorbic acid content of Cornelian cherry fruits, ranging from 28.99 to 103.3 mg per 100 g FW. Tural and Koca [26] found that the ascorbic acid content of the Cornelian cherry ranged between 16 to 88 mg per 100 g. Similar findings (31–112 mg/100 g) were also reported by Yilmaz et al. [15]. Pantelidis et al. [1] reported that the ascorbic acid content of Cornelian cherry (103.3±12.67 mg/100 g) was higher than raspberry (16.8–37.7 mg/100 g) and blackberry (14.3–17.57 mg/100 g) fruits. The Cornelian cherry fruits (59.8±20.6 mg/100 g) seem to be a good source of ascorbic acid when compared strawberry (50.1±2.8 mg/100 g) and kiwi (28–80 mg/100 g) fruits that are accepted as high ascorbic acid source [38, 39].

The antioxidant activity measured using ABTS methods in Cornelian cherry was expressed as µM trolox equivalents per g. The average antioxidant capacity was 46.31±15.06 (Table 2). Similar results (29.48–36.51 mmol/kg) was expressed by Dragovic-Uzelac et al. [28]. Celep et al. [2] reported relatively higher antioxidant activity (103±8.9 µM TEAC/g extract) in Cornelian cherry fruits. The ABTS method is one of the popular assay determine indirectly antioxidant activity. Yilmaz et al. [15] also measured antioxidant capacity in Cornelian cherry fruits using by electron transfer based assay (ferric reducing antioxidant power, FRAP). FRAP values of the fruits (73–114 µmol ascorbic acid/g DW) was high and varied in wide range between the genotype. Pantelidis et al. [1] reported similar FRAP values (83.9±5.4 µmol ascorbic acid/g DW) in Cornelian cherry. Therefore, the Cornelian cherry might be considered as a good source of antioxidant.

Tannin content of fruit might be a main cause for antioxidant activity among the polyphenol compounds (Table 3). The effectiveness on radical species is related with the increasing polymerization degree. Currently, dimeric and oligomeric chatechin supplement extracted from grape seed has been marketed [40]. The degree of polymerization in grape seed about 30, while in the Cornelian cherries about 69 [29]. The antioxidant activities of cherry fruit also are positively related with their degree of polymerization from high to low in order of Cornelian cherry (63), Laurel cherry (45), and sour cherry (4) [29]. Due to relative complexity and diversity of tannins, the structure and activity relationship has not been defined completely yet [40]. The Cornelian cherry tannins might be an alternative antioxidant supplement to grape seed extract.

The Pearson correlation (r) between some investigated parameters in Cornelian cherry was expressed in Table 3. High pearson correlation coefficient was found between antioxidant activity and total phenolic content (r=0.965), total flavonoid content (r=0.890), hydrolysable tannins (r=0.882) and proanthocyanin content (r=0.872). Similarly, Celep et al. [2] reported high correlation coefficients (r=0.8767−0.8964) between phenolic content of Cornelian cherry fruit and TEAC values. Although, Hassanpour et al. [8] was not found correlation (r=0.18) between antioxidant activity and anthocyanin content, the investigated parameter of Cornelian cherry fruit significantly correlated (r=0.857) with antioxidant activity. Our results in agreement with Pantelidis et al. [1], there is a close correlation between antioxidant capacity (FRAP) and anthocyanin content of Cornelian cherry and berry fruits.

Table 3. Pearson correlation coefficient of investigated parameters in Cornelian cherry fruit

Variables	AOA	TPC	FC	ACN	HTC	CT	AsA
AOA	1	0.965**	0.890**	0.857**	0.882**	0.872**	0.746**
TPC		1	0.941**	0.900**	0.889**	0.889**	0.761**
FC			1	0.870**	0.821**	0.824**	0.680**
ACN				1	0.855**	0.861**	0.735**
HTC					1	0.904**	0.797**
CT						1	0.764**
AsA							1

**: Significant at p<0.001

CONCLUSION

Cornelian cherry fruits naturally grown in Çorum/Turkey are a significant source of natural antioxidants: condensed and hydrolysable tannins, anthocyanin and ascorbic acid. Cornelian cherry might be a strong alternative to use as a potential ingredient of nutraceutical or food formulation. Also, the selected promising phenotype might be used for organic production of Cornelian cherry.

ACKNOWLEDGEMENT

The author would like to thank to Hitit University Scientific Research Project Office to financial support of 19003.17.001 numbered project.

REFERENCES

[1] Pantelidis, G.E., Vasilakakis, M., Manganaris, G.A., Diamantidis, G.R. (2007). Antioxidant capacity, phenol, anthocyanin and ascorbic acid contents in raspberries, blackberries, red currants, gooseberries and Cornelian cherries. *Food Chemistry,* 102(3), 777-783.

[2] Celep, E., Aydın, A., Yesilada, E. (2012). A comparative study on the in vitro antioxidant potentials of three edible fruits: Cornelian cherry, Japanese persimmon and cherry laurel. *Food and Chemical Toxicology,* 50(9), 3329-3335.

[3] Dinda, B., Kyriakopoulos, A.M., Dinda, S., Zoumpourlis, V., Thomaidis, N.S., Velegraki, A., Markopoulos, C., Dinda, M. (2016). *Cornus mas* L. (Cornelian cherry), an important European and Asian traditional food and medicine: Ethnomedicine, phytochemistry and pharmacology for its commercial utilization in drug industry. *Journal of Ethnopharmacology,* 163, 670-690.

[4] Seeram, N.P., Schutzki, R., Chandra, A., Nair, M.G. (2002). Characterization, quantification, and bioactivities of anthocyanins in Cornus species. *Journal of Agricultural and Food Chemistry,* 50(9), 2519-2523.

[5] Ozdemir, A.E., Candir, E., Toplu, C., Yildiz, E.R.C.A.N. (2020). Effect of Hot Water Treatment on Astringency Removal in Persimmon Cultivars. *International Journal of Fruit Science,* 1-13.

[6] Chung, K.T., Wong, T.Y., Wei, C.I., Huang, Y.W., Lin, Y. (1998). Tannins and human health: a review. *Critical Reviews in Food Science and Nutrition,* 38(6), 421-464.

[7] Dumitraşcu, L., Enachi, E., Stănciuc, N., Aprodu, I. (2019). Optimization of ultrasound assisted extraction of phenolic compounds from cornelian cherry fruits using response surface methodology. *CyTA-Journal of Food,* 17(1), 814-823.

[8] Hassanpour, H., Yousef, H., Jafar, H., Mohammad, A. (2011). Antioxidant capacity and phytochemical properties of Cornelian cherry (*Cornus mas* L.) genotypes in Iran. *Scientia Horticulturae,* 129(3), 459-463.

[9] Celli, G.B., Ghanem, A., Brooks, M.S.L. (2015). Optimization of ultrasound-assisted extraction of anthocyanins from haskap berries (*Lonicera caerulea* L.) using Response Surface Methodology. *Ultrasonics Sonochemistry,* 27, 449-455.

[10] Jadhav, A.J., Holkar, C.R., Goswami, A.D., Pandit, A.B., Pinjari, D.V. (2016). Acoustic cavitation as a novel approach for extraction of oil from waste date seeds. *ACS Sustainable Chemistry & Engineering,* 4(8), 4256-4263.

[11] Bijelić, S., Gološin, B., Todorović, J.N., Cerović, S. (2011b). Morphological characteristics of best Cornelian cherry (*Cornus mas* L.) genotypes selected in Serbia. *Genetic Resources and Crop Evolution,* 58(5), 689-695.

[12] Pirlak, L., Guleryuz, M., Bolat, I. (2003). Promising cornelian cherries (*Cornus mas* L.) from the Northeastern Anatolia region of Turkey. *Journal of the American Pomological Society,* 57(1), 14.

[13] Demir, F., Kalyoncu, I.H. (2003). Some nutritional, pomological and physical properties of Cornelian cherry (*Cornus mas* L.). *Journal of Food Engineering,* 60(3), 335-341.

[14] Ercisli, S., Orhan, E., Esitken, A., Yildirim, N., Agar, G. (2008). Relationships among some Cornelian cherry genotypes (*Cornus mas* L.) based on RAPD analysis. *Genetic Resources and Crop Evolution,* 55(4), 613.

[15] Yilmaz, K.U., Ercisli, S., Zengin, Y., Sengul, M., Kafkas, E.Y. (2009). Preliminary characterisation of Cornelian cherry (*Cornus mas* L.) genotypes for their physico-chemical properties. *Food Chemistry,* 114(2), 408-412.

[16] S. Ercisli. (2004). Cornelian cherry germplasm resources of Turkey. *Journal of Fruit and Ornamental Plant Research,* 12, 87-92.

[17] Ercisli, S., Yilmaz, S.O., Gadze, J., Dzubur, A., Hadziabulic, S., Aliman, Y. (2011). Some fruit characteristics of Cornelian cherries (*Cornus mas* L.). *Notulae Botanicae Horti Agrobotanici Cluj-Napoca,* 39(1), 255-259.

[18] AOAC, C.A. (2005). Official methods of analysis of the Association of Analytical Chemists International.

[19] Raghu, V., Platel, K., Srinivasan, K. (2007). Comparison of ascorbic acid content of Emblica officinalis fruits determined by different analytical methods. *Journal of Food Composition and Analysis,* 20(6), 529-533.

[20] Singleton, V.L., Orthofer, R., Lamuela-Raventos, R.M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. *Methods Enzymol,* 299, 152-178.

[21] Zhishen, J., Mengcheng, T., Jianming, W. (1999). The determination of flavonoid content in mulberry and their scavenging effects on superoxide radicals. *Food Chemistry,* 64(4), 555-559.

[22] Çam, M., Hışıl, Y. (2010). Pressurised water extraction of polyphenols from pomegranate peels. *Food Chemistry,* 123(3), 878-885.

[23] Tanner, H., Brunner, H.R. (1979). Getraenke Analytik. D-7170. Schwaebisch Hall: Germany: Verlag Heller Chemie-und Verwaltungsgeselschaft mbH.

[24] Giusti, M.M., Wrolstad, R.E. (2001). Anthocyanins. Characterization and measurement with UV-visible spectroscopy, In Current Protocols in Food Analytical Chemistry, Wrolstad, R.E. and Schwartz, S.J. (eds.), p. 1-13, John Wiley & Sons, New York, U.S.A.

[25] Arts, M.J.T.J., Haenen, G.R.M.M., Voss, H.P., Bast, A. (2001). Masking of antioxidant capacity by the interaction of flavonoids with protein. Food and Chemical Toxicology, 39(8), 787-791.

[26] Tural, S., Koca, I. (2008). Physico-chemical and antioxidant properties of cornelian cherry fruits (*Cornus mas* L.) grown in Turkey. *Scientia Horticulturae*, 116(4), 362-366.

[27] Bijelić, S.M., Gološin, B.R., Todorović, J.I.N., Cerović, S.B., Popović, B.M. (2011a). Physicochemical fruit characteristics of Cornelian cherry (*Cornus mas* L.) genotypes from Serbia. *Hortscience*, 46(6), 849-853.

[28] Dragović-Uzelac, V., Levaj, B., Bursać, D., Pedisić, S., Radojčić, I., Biško, A. (2007). Total phenolics and antioxidant capacity assays of selected fruits. *Agriculturae Conspectus Scientificus,* 72(4), 279-284.

[29] Capanoglu, E., Boyacioglu, D., de Vos, R. C., Hall, R.D., Beekwilder, J. (2011). Procyanidins in fruit from Sour cherry (*Prunus cerasus*) differ strongly in chainlength from those in Laurel cherry (*Prunus lauracerasus*) and Cornelian cherry (*Cornus mas*). *Journal of Berry Research*, 1(3), 137-146.

[30] Pawlowska, A.M., Camangi, F., Braca, A. (2010). Quali-quantitative analysis of flavonoids of *Cornus mas* L. (Cornaceae) fruits. *Food Chemistry,* 119(3), 1257-1261.

[31] Kent, K., Charlton, K., O'Sullivan, T., Oddy, W.H. (2020). Estimated intake and major food sources of flavonoids among Australian adolescents. *European Journal of Nutrition,* 1-16.

[32] Einbond, L.S., Reynertson, K.A., Luo, X.D., Basile, M.J., Kennelly, E.J. (2004). Anthocyanin antioxidants from edible fruits. *Food Chemistry,* 84(1), 23-28.

[33] Wang, W., Jung, J., Tomasino, E., Zhao, Y. (2016). Optimization of solvent and ultrasound-assisted extraction for different anthocyanin rich fruit and their effects on anthocyanin compositions. *LWT-Food Science and Technology,* 72, 229-238.

[34] Beecher, G.R. (2003). Overview of dietary flavonoids: nomenclature, occurrence and intake. *The Journal of Nutrition,* 133(10), 3248S-3254S.

[35] Milenković-Anđelković, A.S., Anđelković, M.Z., Radovanović, A.N., Radovanović, B.C., Nikolić, V. (2015). Phenol composition, DPPH radical scavenging and antimicrobial activity of Cornelian cherry (*Cornus mas*) fruit and leaf extracts. *Hemijska Industrija,* 69(4), 331-337.

[36] Yang, B., Liu, P. (2014). Composition and biological activities of hydrolyzable tannins of fruits of Phyllanthus emblica. *Journal of Agricultural and Food Chemistry,* 62(3), 529-541.

[37] Dokhanieh, A.Y., Aghdam, M.S., Fard, J.R., Hassanpour, H. (2013). Postharvest salicylic acid treatment enhances antioxidant potential of cornelian cherry fruit. *Scientia Horticulturae,* 154, 31-36.

[38] Nishiyama, I., Yamashita, Y., Yamanaka, M., Shimohashi, A., Fukuda, T., Oota, T. (2004). Varietal difference in vitamin C content in the fruit of kiwifruit and other Actinidia species. *Journal of Agricultural and Food Chemistry,* 52, 5472-5475.

[39] Martinsen, B.K., Aaby, K., Skrede, G. (2020). Effect of temperature on stability of anthocyanins, ascorbic acid and color in strawberry and raspberry jams. *Food Chemistry,* 316, 126297.

[40] Heim, K.E., Tagliaferro, A.R., Bobilya, D.J. (2002). Flavonoid antioxidants: chemistry, metabolism and structure-activity relationships. *The Journal of Nutritional Biochemistry*, 13(10), 572-584.